PATENT ABSTRACTS OF JAPAN

(11)Publication number : **07-148143**
(43)Date of publication of application : **13.06.1995**

(51)Int.Cl. **A61B 6/00**
A61B 6/00

(21)Application number : **05-296558**
(22)Date of filing : **26.11.1993**

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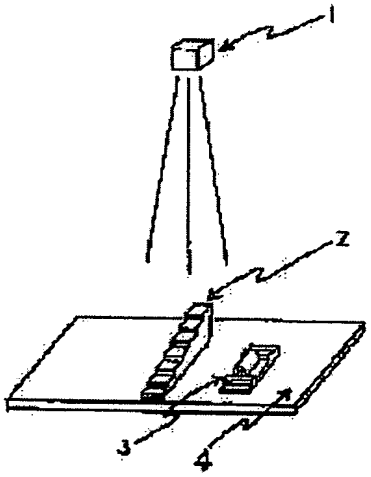
(54) METHOD OF MEASURING BONE SIZE AND DEVICE FOR THE SAME

(57)Abstract:

PURPOSE: To reduce the difference of the measurement results between facilities or change of the measurement results with time in the same facility by converting the measurement results in different facilities in accordance with a correction formula obtained using at least one standard phantom.

CONSTITUTION: In a method of measuring a bone, a standard phantom 3 is photographed instead of a bone together with a standard matter 2 by an X-ray photographing device 1. Subsequently, on the basis of the measurement result obtained by a predetermined method, a correction formula is determined for reducing the difference of the measurement results between facilities or correcting the change of the measurement results with time in the same facility. Examples of the above-mentioned method for measuring a bone include those which use one standard phantom or at least two standard phantoms having different measurement results and a correction formula comprising offset correction terms or those which use at least two standard phantoms having different measurement results and a correction formula comprising gain offset correction terms. By using the correction formula thus obtained for measuring a bone, it is possible to more accurately compare the measurement results of bones of different examinees.



CLAIMS

[Claim(s)]

[Claim 1] The photoelectrical signal based on the image about the tested bone which was radiographed with the standard substance from which thickness is changing, and was obtained In the osteometry approach which property-conversion-measures this tested bone for the property of a photoelectrical signal with an inverse function or its approximation function on the basis of the thickness of this standard substance using a computer means A criteria phantom is radiographed with this standard substance instead of a tested bone. The osteometry approach characterized by asking for the correction formula for amending contraction and/or aging in a facility for the difference between facilities beforehand based on the measurement result when measuring by the predetermined osteometry approach, and using this correction formula at the time of measurement of a tested bone.

[Claim 2] It is the approach of claim 1 that this criteria phantom uses one kind and a correction formula consists of an offset correction term.

[Claim 3] It is the approach of claim 1 that this criteria phantom uses two or more kinds from which a measurement result differs, and a correction formula consists of an offset correction term.

[Claim 4] It is the approach of claim 1 that this criteria phantom uses two or more kinds from which a measurement result differs, and a correction formula consists of a correction term of gain offset.

[Claim 5] Two or more kinds of criteria phantoms are the approaches of claims 3 or 4 which are made close on an one X-ray photograph film, and are photoed with this standard substance.

[Claim 6] Two or more kinds of criteria phantoms are the approaches of claims 3 or 4 photoed separately in the same location.

[Claim 7] Aging in a facility is the approach of claim 1 using the correction formula which consists of a correction term of the offset acquired using one kind of criteria phantom using the correction formula which the difference between facilities becomes from the correction term of the gain offset acquired using two or more kinds of criteria phantoms from which a measurement result differs.

[Claim 8] A means to acquire the photoelectrical signal based on the image about the tested bone radiographed with the standard substance from which thickness is changing, In osteometry equipment equipped with the processing means for property-conversion-measuring this tested bone for the property of a photoelectrical signal with an inverse function or its approximation function on the basis of the thickness of this standard substance This processing means A criteria phantom is radiographed with this standard substance instead of a tested bone. By the predetermined osteometry approach Osteometry equipment characterized by using the correction formula for carrying out contraction of the difference between facilities beforehand searched for based on the measurement result when measuring, and/or amendment of aging in a facility.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the osteometry approach and osteometry equipment. Furthermore, this invention provides a detail with the approach of reducing the effect of aging produced through the time amount more than extent which is in the difference between facilities in the equipment which measures a bone gestalt etc. using the image in the X-ray photograph film of a tested bone, or the same facility.
[0002]
[Description of the Prior Art] There is the MD method ("bone metabolic turnover" reference, such as the 13th volume, 187 - 195 pages (1980), the 14th volume, and 91 - 104 etc. pages (1981)) for measuring the shade of the image in the film by the microdensitometer using the X-ray photograph film obtained by carrying out X-ray irradiation to a tested bone as an application of image reading of an X-ray photograph film, and performing an osteometry etc. In addition, it is easy to adopt the MD method at the point using the X-ray photograph film easily obtained using the photography equipment of the X-ray image which has spread widely as equipment for a diagnosis of fracture etc., and it is spreading widely gradually.
[0003] The osteometry by the old MD method had many parts by handicraft as follows. That is, the part (for example, part on the cross cut in the midpoint of the major axis of the 2nd os metacarpale) which carries out an osteometry to a detail with the method which is handicraft, defined the criteria point required for the osteometry by the MD method about the image of the bone in a film, and was first defined further using the criteria point is selected using the X-ray photograph film obtained by the tested bone by irradiating an X-ray. Subsequently, making microdensitometer scan to the selected part, the reinforcement of the transmitted light obtained by irradiating light to the part is measured, and the diagram of the reinforcement of the transmitted light corresponding to the scanned part or an absorbance is made to indicate in the predetermined chart paper. Microdensitometer is made to scan on the vertical section line of the image in the film of the stair-like reference material made from aluminum (henceforth an aluminum stairway) by which roentgenography was furthermore carried out with the tested bone, and a chart is made to also indicate the diagram of the reinforcement of the obtained transmitted light, or an absorbance. Each diagram of the absorbance about the tested bone chart in the paper it was obtained in this way, and the absorbance about an aluminum stairway is inputted into a computer using a digitizer, and the absorbance of a tested bone is changed into the number of stages of an aluminum stairway on each point. Thus, the various indexes of expressing the bone gestalt in an object part are calculated within a computer using drawing which was changed and was obtained, and a count result is outputted.
[0004] The image reader for this MD method etc. is indicated by JP,3-215256,A, and image sensors, such as CCD (ChargedCoupled Device) for reading the quantity of light which has penetrated the X-ray photograph film, using the band-like light sources, such as LED (Light Emitting Diode), as an optical generating means for irradiating for example, an X-ray photograph film here, are used for it. The amount of transmitted lights is changed into an analog electrical signal by the sensor, an AD translation is carried out further, and it becomes a digital signal, and transform processing of the amount signal of transmitted lights from a tested bone is carried out to standard substance thickness by MPU (Micro Proccessing Unit) using the amount signal of transmitted lights of the standard substance read beforehand, and the bone mineral content after pattern processing is computed.
[0005] However, there was a trouble that a measurement result changed about the osteometry by the old osteometry accompanied by roentgenography with fluctuation of the development conditions of the film in the case of using roentgenography conditions, X-ray intensity nonuniformity, and an X-ray photograph film etc. Since it passes the time amount more than extent set between facilities or to the same facility even when this difference became a cause and measured the same analyte, when it measured, the difference might be produced in the measurement result.

[0006]
[Problem(s) to be Solved by the Invention] This invention is a difference between facilities by the condition difference, engine-performance difference, etc. of processors, such as X-rays equipment and development, Or the difference of the measurement result in the facility which passed through the above time amount to some extent is made to reduce, and it aims at enabling it to perform comparison and examination of the measurement result between the facilities in a facility with a more sufficient precision.
[0007]
[Means for Solving the Problem] In order to attain this purpose, as a result of inquiring wholeheartedly, this invention persons drew the correction formula using one kind or two kinds or more of criteria phantoms beforehand, by reconverting the measurement result of each facility based on this correction formula, found out that the difference between facilities or the difference in the facility which passed through the above time amount to some extent was reducible, and reached this invention.
[0008] This invention namely, the photoelectrical signal based on the image about the tested bone radiographed with the standard substance from which thickness is changing In the osteometry approach which carries out property conversion of the property of a photoelectrical signal with an inverse function or its approximation function based on the thickness of this standard substance using a computer means, and measures this tested bone A criteria phantom is radiographed with this standard substance instead of a tested bone. Based on the measurement result when measuring by the predetermined osteometry approach, it asks for the correction formula for amending contraction or aging in a facility for the difference between facilities beforehand, and the osteometry approach characterized by using this correction formula at the time of measurement of a tested bone is offered. In addition, although a gamma ray and an X-ray are contained in a radiation, an X-ray is raised as a thing suitable for this invention here. Moreover, as the standard substance, the shape of a slope and the stair-like thing made from aluminum are raised.
[0009] (1) this criteria phantom uses one kind for the osteometry approach of this this invention, when a correction formula is what consists of an offset correction term, (2) this criteria phantom uses two or more kinds from which a measurement result differs, when a correction formula is what consists of an offset correction term, (3) this criteria phantom uses further two or more kinds from which a measurement result differs, and the case where a correction formula is what consists of a correction term of gain offset is included.
[0010] The osteometry approach by which two or more kinds of criteria phantoms are furthermore photoed about the above (2) and (3) in the same location separately [the osteometry approach which is made close on an one X-ray photograph film etc., and is photoed with this standard substance, and two or more kinds of criteria phantoms] is raised.
[0011] Moreover, the osteometry approach using the correction formula which consists of a correction term of the offset from which aging in a facility is obtained using one kind of criteria phantom is included in the approach of above-mentioned this invention using the correction formula which the difference between facilities becomes from the correction term of the gain offset acquired using two or more kinds of criteria phantoms from which a measurement result differs.
[0012] A means to acquire the photoelectrical signal based on the image about the tested bone with which this invention was radiographed with the standard substance from which thickness is changing furthermore, In osteometry equipment equipped with the processing means for property-conversion-measuring this tested bone for the property of a photoelectrical signal with an inverse function or its approximation function on the basis of the thickness of this standard substance This processing means A criteria phantom is radiographed with this standard substance instead of a tested bone. By the predetermined osteometry approach The osteometry equipment characterized by using the correction formula for carrying out contraction of the difference between facilities beforehand searched for based on the measurement result when measuring or amendment of aging in a facility is offered.
[0013] The facility in this invention means the facility where roentgenography is performed, and

usually means a hospital etc.
[0014]
[Function] Therefore, this invention can observe a change of the bone measurement result of the same subject with time with a more sufficient precision in a facility by having provided the above means. Moreover, the bone measurement result between subject can be further compared with a more sufficient precision between facilities in a facility.
[0015]
[Example] Hereafter, one example of this invention is explained with reference to drawing 1 -17.
[0016] When the osteometry approach of this invention uses the image in an X-ray photograph film, generally photography of the X-ray photograph film for osteometries is performed by approach like drawing 1 .
[0017] At this time, the wavelength of the X-ray generated from X-rays equipment changes with set-up tube voltage (drawing 2). Therefore, the mass attenuation coefficient mu showing the ease of penetrating of the X-ray when penetrating the specimen changes (drawing 3). In fact, in case a photograph is taken with X-rays equipment, how depending on which tube voltage is unsteady by a certain within the limits (refer to the example of a tube voltage wave of drawing 4), and tube voltage is unsteady according to change of the class of equipment and the operating environment of the day as a result is also different. The difference in the measurement result by the difference in tube voltage is shown in drawing 5 . This shows that the difference of X-rays equipment is one of the causes of the difference between facilities, or ****** in the same facility.
[0018] Furthermore, in case the photoed X-ray photograph film is developed, generally an auto-processor is used (drawing 6 R>6). However, development nonuniformity is made to the longitudinal direction of the roller for X-ray photograph film advances which is not concerned with the right and wrong of the engine performance of equipment in an auto-processor, but is in the interior (drawing 7 R>7). When decrease of the X-ray by the distance from X line source is considered in addition to this, it turns out that very big nonuniformity is on an X-ray photograph film. This error is also known by that it is one of the causes of the difference between facilities, or ****** in the same facility.
[0019] the above factors sake — for example, the 2nd — the os metacarpale — even if it measures after photoing the same analyte, the measurement result of the obtained osteometry has a difference like drawing 8 between facilities. If area sigmaGS and sigmaGS/D of the slash section which can be put on the absorbance pattern about the midpoint of the 2nd os metacarpale in the X-ray photograph film of drawing 9 are calculated about each data, the size of a measurement result and very good correlation will be found like drawing 10 . Then, I thought that the difference between facilities could be made small by amending sigmaGS.
[0020] Below, the approach of sigmaGS amendment which is the example of amendment by the correction formula in the osteometry approach of this invention is explained at a detail.
[0021] The criteria phantom in this invention is having structure like drawing 11 , and consists of false soft tissue 8 and a false bone 9. Although the false soft tissue 8 and the false bone 9 consist of pure aluminum (A1080), other matter is sufficient as hydroxyapatite etc. The measurement result in the number facility of three kinds of criteria phantoms to which only the bore of this false bone 9 was changed becomes as it is shown in drawing 1212 . It is Y when an offset multiplier [in /for the multiplier which expresses the increment degree of the measurement result of the criteria phantom which is three kinds from which a bore is different from this drawing /a and each facility] is set to b. =aX +It can approximate with b. Here, Y is sigmaGS of an observation result and X is the design value of sigmaGS of each criteria phantom. Also in all facilities, since the multiplier a showing the increment degree of a measurement result is the same (refer to Table 1) mostly, also by adjusting the offset multiplier b, it can maintain a certain amount of precision, and can amend the difference between facilities.
[0022] Table 1 shows gain when sigmaGS /D design value of each criteria phantom are taken along an axis of abscissa and it takes sigmaGS /D measured value of each criteria phantom along an axis of ordinate, and offset.
[0023]

[Table 1]

施　設	ゲ　イ　ン	オフセット
施設A	+1.0416	−0.5148
施設B	+0.9793	−0.4521
施設C	+1.0655	−1.0874
施設D	+1.0139	−0.0928

[0024] Below, the example of the amendment approach between the facilities by the degree of the offset multiplier b is explained at a detail.
[0025] Photography of an X-ray photograph film required for this osteometry approach is performed by carrying out like drawing 1 . The cassette of dedication by which 1 put X-rays equipment and 4 put an X-ray photograph film and the intensifying screen in drawing 1 , and 3 are criteria phantoms. The photoed X-ray photograph film is developed by an auto-processor, similar equipment, or the help. An example of a criteria phantom configuration is shown in drawing 11 . The same criteria phantom is measured after photography by the same approach also in other facilities. Distribution between two or more facilities of the measurement result of sigmaGS about a criteria phantom is shown in drawing 8 .
[0026] From the measurement result obtained in each facility, a degree type determines the offset multiplier of each facility proper.
[0027]
[Equation 1]

$$b = \frac{1}{n}\sum_{k=1}^{n}\left(\Sigma GS_{meas} - \Sigma GS_{dsgn}\right)$$

$$= \frac{1}{n}\sum_{k=1}^{n}\left\{D_{meas} \times \left(\Sigma GS/D_{meas}\right) - D_{dsgn} \times \left(\Sigma GS/D_{dsgn}\right)\right\}$$

[0028] Here, sigma (k=1-n) of an upper type is the sum about the criteria phantom in all facilities. Moreover, Dmeas is the measured value of the criteria phantom dimension in each facility. sigmaGS/Dmeas is the measured value of the bone measurement result of the criteria phantom in each facility. Ddsgn is the design value of the dimension of a criteria phantom, and sigmaGS/Dmeas is the design value of the osteometry result of a criteria phantom. The osteometry result amended between facilities as a result is calculated by the degree type. Here, sigmaGS/Dmdfd is as a result of [after amendment] an osteometry.
[0029]
[Equation 2]

$$\Sigma GS/D_{mdfd} = \frac{\Sigma GS/D_{meas} \times D_{meas} - b}{D_{meas}}$$

[0030] Even if it measures the same criteria phantom with the osteometry equipment after

photography as a result, a thing with distribution between facilities like drawing 8 can amend to the distribution which does not almost have a difference between facilities like drawing 13 .
[0031] When only offset was amended as mentioned above, it turned out that the difference between facilities is reducible as shown in Table 2, but if amendment between facilities with a more high precision is performed, it is necessary to also adjust gain factor a showing the increment degree of a measurement result, and to perform amendment between facilities.
[0032] Table 2 shows the effectiveness when performing offset amendment in the equipment of this invention.
[0033]
[Table 2]

		基準ファントム		
		骨細	標準	骨太
施設A		1.7919	2.1849	2.4994
施設B		1.9046	2.2434	2.5892
施設C		1.8245	2.2205	2.5608
施設D		1.8751	2.2185	2.5830
施設間差	補正後	0.1127	0.0585	0.0898
	補正前	0.1189	0.1455	0.1445

[0034] Below, the example of the amendment approach between gain factor a and the facility by the degree of the offset multiplier b is explained at a detail.
[0035] Photography of an X-ray photograph film required for this osteometry approach of this invention is performed by carrying out like drawing 1 . The cassette of dedication by which 1 put X-rays equipment and 4 put an X-ray photograph film and the intensifying screen in drawing 1 , and 3 are criteria phantoms. The photoed X-ray photograph film is developed by an auto-processor, similar equipment, or the help. Although a criteria phantom should just use two or more kinds of things, it uses three kinds of things here. The configuration of a criteria phantom is shown in drawing 11 . Furthermore, the example of the geometry of each criteria phantom is shown in Table 3. Three kinds of criteria phantoms are measured after photography by the same approach also in other facilities. Distribution between the facilities of the measurement result of each criteria phantom is shown in drawing 12 .
[0036] Table 3 shows the bore and outer diameter of a criteria phantom of three types in the equipment of this invention.
[0037]
[Table 3]

基準ファントム	内径 mm	外径 mm
骨細タイプ	3．4	5．0
標準タイプ	3．0	5．0
骨太タイプ	2．6	5．0

寸法公差：±0．02

[0038] It sets to each facility and is [0039].
[Equation 3]
X軸を

$$\Sigma GS_{dsgn} = \Sigma GS/D_{dsgn} \times D_{dsgn}$$

Y軸を

$$\Delta = \Sigma GS/D_{meas} \times D_{meas} - \Sigma GS/D_{dsgn} \times D_{dsgn}$$

[0040] A degree type is obtained by writing the graph (drawing 14) carried out and recurring temporarily.
[0041]
[Equation 4]

$$\Delta_{revolved} = a \times \Sigma GS_{dsgn} + b$$

[0042] Here, ** and a **revolved was presumed to be by primary recursion express a gain factor, and b expresses an offset multiplier. Bone measurement result sigmaGS/Dmeas can be amended to a value with few differences between facilities using this formula. A correction formula is shown by the degree type.
[0043]
[Equation 5]

$$\Sigma GS/D_{mdfd} = \frac{\Sigma GS/D_{meas} \times D_{meas} - b}{(1 + a) \times D_{meas}}$$

[0044] Here, sigmaGS/Dmdfd is as a result of [after amendment] an osteometry. As a result, even if it measures three kinds of criteria phantoms with the osteometry equipment after photography, a thing with distribution between facilities like drawing 12 can amend to the distribution which does not almost have a difference between facilities like drawing 15 . Moreover, even if it sees with the difference between facilities, effectiveness as shown in Table 4 is accepted.
[0045] Table 4 shows the effectiveness when performing gain offset amendment in the equipment of this invention.
[0046]
[Table 4]

		基準ファントム		
		骨細	標準	骨太
施設A		1.8439	2.2226	2.5249
施設B		1.8599	2.2046	2.5575
施設C		1.8402	2.2130	2.5335
施設D		1.8512	2.1901	2.5498
施設間差	補正後	0.0197	0.0325	0.0326
	補正前	0.1189	0.1455	0.1445

[0047] The tested bone needed when performing various osteometries, such as a check of the range of the class of osseous lesions, such as a growth condition of human being's bone, a check of seniliy or osteoporosis, and osteomalacia, or the percentage of completion of the symptom, and the effectiveness at the time of a therapy, as an example of analyte applicable to the osteometry approach of this invention is raised. Be [what is necessary /just although an X-ray photograph film with whenever /to some extent clear shading /is obtained as a tested bone in the case of using an X-ray photograph film], what the layer of the soft tissue section is usually equalizing thinly is desirable. As an example, the long long bone which consists of cortical bones, such as a bone of hand, a humerus, a radius, an ulna, a femur, a tibia, and a fibula, is raised. As other examples of a tested bone applicable to the equipment of this invention furthermore, cancellous bones, such as an epiphyseal area of a calcaneus, a spine, and the above-mentioned long long bone, are raised. Moreover, as long as it is required to convert into the thickness of the standard substance and to evaluate through an X-ray photograph film as other specimen, you may be what kind of thing.

[0048] The osteometry equipment of this invention is characterized by having a configuration for enforcing this osteometry approach. Drawing 16 is typically shown as a desirable example of a mode of the osteometry equipment of this invention. In this drawing, a generating means (light source) of light by which the automatic reading function part 10 irradiates an X-ray photograph film, the detection means for detecting the reinforcement of the transmitted light to which the light from that light source penetrated the X-ray photograph film, and in order to make it run an X-ray photograph film automatically, it has a film automatic transit means.

[0049] Although spot-like light is generated as this light source, in order a scanning means is usually needed and to make it the equipment which is small and simple structure, the band-like light source for generating a band-like light is suitable practically. Moreover, the transmitted light is detectable, and corresponding to it, adhesion image sensors band-like in a band-like sensor, i.e., a line sensor, are desirable especially desirable [as long as automatic reading is possible, what kind of thing may be used but] as a detection means, when using the band-like light source practically. It may be other, although a roller is usually used as a transit means of a film and the roller of a pair which rotates to an opposite direction mutually on both sides of a film in between especially is used suitably. In addition, as long as it can run an X-ray photograph film as an automatic transit means of a film at the rate of predetermined with the rate which suited the detection rate of a detection means, you may be what kind of thing, and a transit format may be

continuous or may be intermittent.
[0050] As for the osteometry equipment of this invention, it is desirable to provide an image storage means. If the data constellation which made the digital signal about the reinforcement of the transmitted light in the image in the X-ray photograph film of the tested bone obtained by the automatic reading means like the above correspond to the location of a film as this image storage means, or the data constellation about the image converted into the thickness of a reference material can be memorized, you may be what kind of thing and the storage memory size will be chosen according to the purpose of an osteometry. As an example, the computer means like about 2 M bytes of image memory etc. is raised in the osteometry of the 2nd os metacarpale.
[0051] Moreover, to the equipment of this invention, an operation means to perform various processings for performing an osteometry using the image read in the film possesses.
[0052] Moreover, as shown in the equipment of this invention at drawing 16 , were read by the image reading means. Or the image display means like CRT (Cathode Ray Tube) for displaying as an image the image of the tested bone memorized by the storage means, Equipment with the operation means for performing the operation for the osteometry about the image of the tested bone memorized using the criteria point inputted as the point input means for inputting the criteria point required for an osteometry in the image of the displayed tested bone is contained.
[0053] If the data constellation which consists of relation of the digital signal and location which were memorized or obtained by the image storage means with the automatic reading means as this image display means can be displayed as an image, you may be what kind of thing and CRT etc. will specifically be raised from the cost of resolution as a suitable example.
[0054] for example, as a point input means for inputting the point of the criteria in the case of asking for the midpoint of the 2nd os metacarpale by the image of CRT As long as it can pinpoint and input a location as the criteria point in an image display means, you may be what kind of thing. As an example The approach of inputting automatically etc. is raised from the image of the tested bone memorized by the approach list inputted from the exterior with a cursor location display, a directions control means, a light pen blocking force means, and a touch panel.
[0055] Come, whenever it is shown in drawing 16 , and the equipment of this invention is made to memorize the location of the criteria point inputted by the point input means in the image display means before adjusting the quantity of light of the light source with storage means, such as RAM. Subsequently, like the above, the film of the same part is again read with the accommodation quantity of light after adjusting the quantity of light based on a judgment result, and the thing possessing the means for carrying out a point input based on the criteria point already memorized by RAM in the image displayed on the display means is contained. Actuation of these single strings is made by the image reading function part 10 which operates by control of MPU in drawing 16 . When resetting of the exposure quantity of light is made and it differs from the set point last time by this configuration, a film is automatically sent to an aluminum stairway and an object part, and since the last point input value is memorized and processing is automatically performed in the location when the point input of the part for reading is required, the burden of the operator for reinput can be reduced.
[0056] Moreover, if the measurement result obtained by the operation can be outputted as an osteometry output means in the osteometry equipment of this invention, you may be what kind of thing and a dot type ink printer, a thermal printer, a laser beam printer, a video printer, other CRT screens, etc. will be raised to hard copy as an example.
[0057] In addition, in the reading function part 10 shown in drawing 16 , the line sensor (CCD:Charged Coupled Device) which consists of 65-micrometer pitch x4096 child, for example is arranged in a right angle in the film migration direction. A film is irradiated according to the band-like light source (LED:Light Emitting Diode) from an X-ray photograph film top face or an inferior surface of tongue. The transmitted light is condensed in this film reflector by the rod lens arranged so that a focus may be connected on a line sensor. The very small film transit means using the pulse motor which can carry out very small migration in 65-micrometer pitch is provided in a line sensor and the band-like light source, and the direction of a right angle at the same time it acquires signals, such as reinforcement of the transmitted light according to the X-

ray photograph film density. Moreover, each component of a line sensor outputs the analog voltage proportional to the amount of incident light to a line sensor (= the amount of transmitted lights according to the shade to a film).

[0058] To the specific part in this X-ray photograph film, a crimp enables detection of the transmitted light or the control means for controlling making it run a film intermittently at the rate of predetermined is illustrated as a film feed controller in drawing 16 .

[0059] In addition, the CCD driver in drawing 16 has the function controlled to be able to take out the data stored in CCD to predetermined timing.

[0060] Moreover, in the osteometry data processing function section in drawing 16 , the data constellation read by the reading function part 10 is memorized by the image storage means which mainly consists of the image I/O section and image memory in the data-processing section 11. The data constellation about the memorized image is displayed by CRTC and CRT.

[0061] Since the image of the os metacarpale is displayed and a measurement part is pinpointed by 7 inch CRT (640 dots x 400 lines) which has an image display means and a point input means, cursor is moved and the condyle and epiphysis are directed. This point input means is shown as KBI/F and a keyboard in drawing 16 .

[0062] The operation for an osteometry is performed in the operation means which mainly consists of ROM (program store section for an operation) and RAM (part which calculates and memorizes a result) in drawing 16 .

[0063] The obtained osteometry result is outputted by the output means which mainly consists of PRI/F and the printer in drawing 16 . It is for connecting with RS-232C and MODEMF, and other equipments.

[0064] MPU in drawing 16 is a 16-bit microprocessor which controls incorporation of the data to image memory, a startup and halt of a program, a keyboard, CRT, etc. other than the above mentioned function, and PIO functions as an interface for outputting and inputting digital control I/O to the above-mentioned computer system.

[0065] About use of the correction formula which is the description of the equipment of this invention, a phantom is beforehand changed, for example in a facility, an osteometry is performed, the multiplier of the correction formula is inputted into the equipment of drawing 16 , and ROM is made to ask for the correction formula and to memorize it like the above-mentioned. In the case of actual measurement of a tested bone, the correction formula which used those multipliers in ROM is adopted, and it is made to process an osteometry at it.

[0066] Although the example mentioned above showed what used the X-ray photograph film, this invention is easily applicable to the equipment which irradiates and images a direct X-ray to X-ray image sensors. The flow to an osteometry is typically shown in drawing 17 from the roentgenography in the case of this equipment.

[0067] In the equipment which irradiates and images a direct X-ray to X-ray image sensors, roentgenography can be performed using an imaging plate 12 instead of the cassette which put the X-ray photograph film in the conventional roentgenography, and the information which is proportional to the X-ray information by which are recording record was carried out at this imaging plate 12 by the laser Mitsuteru gunner stage 13 and the optical detection sensor 14 by irradiating laser light at X-ray intensity can be read as a lightwave signal. A/D conversion of the read photoelectrical information is carried out, and X-ray image 15 of a tested bone is obtained. An osteometry with this X-ray image equivalent to the osteometry approach in this invention can be performed.

[0068]

[Effect of the Invention] After drawing the correction formula of the difference between facilities using a criteria phantom, since the correction formula is used for it and it reconverts a measurement result, this invention can make small the difference between facilities when measuring the same specimen, and the difference of the measurement result in the facility which passed through the above time amount to some extent. As a result, the measurement result comparison between facilities, a change of a certain subject in a facility with time, etc. can be compared with a sufficient precision.

OPERATION

[Function] Therefore, this invention can observe a change of the bone measurement result of the same subject with time with a more sufficient precision in a facility by having provided the above means. Moreover, the bone measurement result between subject can be further compared with a more sufficient precision between facilities in a facility.

EXAMPLE

[Example] Hereafter, one example of this invention is explained with reference to drawing 1 -17.
[0016] When the osteometry approach of this invention uses the image in an X-ray photograph film, generally photography of the X-ray photograph film for osteometries is performed by approach like drawing 1 .
[0017] At this time, the wavelength of the X-ray generated from X-rays equipment changes with set-up tube voltage (drawing 2). Therefore, the mass attenuation coefficient mu showing the ease of penetrating of the X-ray when penetrating the specimen changes (drawing 3). In fact, in case a photograph is taken with X-rays equipment, how depending on which tube voltage is unsteady by a certain within the limits (refer to the example of a tube voltage wave of drawing 4), and tube voltage is unsteady according to change of the class of equipment and the operating environment of the day as a result is also different. The difference in the measurement result by the difference in tube voltage is shown in drawing 5 . This shows that the difference of X-rays equipment is one of the causes of the difference between facilities, or ****** in the same facility.
[0018] Furthermore, in case the photoed X-ray photograph film is developed, generally an auto-processor is used (drawing 6 R>6). However, development nonuniformity is made to the longitudinal direction of the roller for X-ray photograph film advances which is not concerned with the right and wrong of the engine performance of equipment in an auto-processor, but is in the interior (drawing 7 R>7). When decrease of the X-ray by the distance from X line source is considered in addition to this, it turns out that very big nonuniformity is on an X-ray photograph film. This error is also known by that it is one of the causes of the difference between facilities, or ****** in the same facility.
[0019] the above factors sake — for example, the 2nd — the os metacarpale — even if it measures after photoing the same analyte, the measurement result of the obtained osteometry has a difference like drawing 8 between facilities. If area sigmaGS and sigmaGS/D of the slash section which can be put on the absorbance pattern about the midpoint of the 2nd os metacarpale in the X-ray photograph film of drawing 9 are calculated about each data, the size of a measurement result and very good correlation will be found like drawing 10 . Then, I thought that the difference between facilities could be made small by amending sigmaGS.
[0020] Below, the approach of sigmaGS amendment which is the example of amendment by the correction formula in the osteometry approach of this invention is explained at a detail.
[0021] The criteria phantom in this invention is having structure like drawing 11 , and consists of false soft tissue 8 and a false bone 9. Although the false soft tissue 8 and the false bone 9 consist of pure aluminum (A1080), other matter is sufficient as hydroxyapatite etc. The measurement result in the number facility of three kinds of criteria phantoms to which only the bore of this false bone 9 was changed becomes as it is shown in drawing 1212 . It is Y when an offset multiplier [in /for the multiplier which expresses the increment degree of the measurement result of the criteria phantom which is three kinds from which a bore is different from this drawing /a and each facility] is set to b. =aX + It can approximate with b. Here, Y is sigmaGS of an observation result and X is the design value of sigmaGS of each criteria phantom. Also in all facilities, since the multiplier a showing the increment degree of a measurement result is the same (refer to Table 1) mostly, also by adjusting the offset multiplier b, it can maintain a certain amount of precision, and can amend the difference between facilities.
[0022] Table 1 shows gain when sigmaGS /D design value of each criteria phantom are taken along an axis of abscissa and it takes sigmaGS /D measured value of each criteria phantom along an axis of ordinate, and offset.
[0023]
[Table 1]

施　設	ゲ　イ　ン	オフセット
施設A	+1.0416	−0.5148
施設B	+0.9793	−0.4521
施設C	+1.0655	−1.0874
施設D	+1.0139	−0.0928

[0024] Below, the example of the amendment approach between the facilities by the degree of the offset multiplier b is explained at a detail.
[0025] Photography of an X-ray photograph film required for this osteometry approach is performed by carrying out like drawing 1 . The cassette of dedication by which 1 put X-rays equipment and 4 put an X-ray photograph film and the intensifying screen in drawing 1 , and 3 are criteria phantoms. The photoed X-ray photograph film is developed by an auto-processor, similar equipment, or the help. An example of a criteria phantom configuration is shown in drawing 11 . The same criteria phantom is measured after photography by the same approach also in other facilities. Distribution between two or more facilities of the measurement result of sigmaGS about a criteria phantom is shown in drawing 8 .
[0026] From the measurement result obtained in each facility, a degree type determines the offset multiplier of each facility proper.
[0027]
[Equation 1]

$$b = \frac{1}{n}\sum_{k=1}^{n}(\Sigma GS_{meas} - \Sigma GS_{dsgn})$$

$$= \frac{1}{n}\sum_{k=1}^{n}\{D_{meas} \times (\Sigma GS/D_{meas}) - D_{dsgn} \times (\Sigma GS/D_{dsgn})\}$$

[0028] Here, sigma (k=1-n) of an upper type is the sum about the criteria phantom in all facilities. Moreover, Dmeas is the measured value of the criteria phantom dimension in each facility. sigmaGS/Dmeas is the measured value of the bone measurement result of the criteria phantom in each facility. Ddsgn is the design value of the dimension of a criteria phantom, and sigmaGS/Dmeas is the design value of the osteometry result of a criteria phantom. The osteometry result amended between facilities as a result is calculated by the degree type. Here, sigmaGS/Dmdfd is as a result of [after amendment] an osteometry.
[0029]
[Equation 2]

$$\Sigma GS/D_{mdfd} = \frac{\Sigma GS/D_{meas} \times D_{meas} - b}{D_{meas}}$$

[0030] Even if it measures the same criteria phantom with the osteometry equipment after photography as a result, a thing with distribution between facilities like drawing 8 can amend to

the distribution which does not almost have a difference between facilities like drawing 13 .
[0031] When only offset was amended as mentioned above, it turned out that the difference between facilities is reducible as shown in Table 2, but if amendment between facilities with a more high precision is performed, it is necessary to also adjust gain factor a showing the increment degree of a measurement result, and to perform amendment between facilities.
[0032] Table 2 shows the effectiveness when performing offset amendment in the equipment of this invention.
[0033]
[Table 2]

		基準ファントム		
		骨細	標準	骨太
施設A		1.7919	2.1849	2.4994
施設B		1.9046	2.2434	2.5892
施設C		1.8245	2.2205	2.5608
施設D		1.8751	2.2185	2.5830
施設間差	補正後	0.1127	0.0585	0.0898
	補正前	0.1189	0.1455	0.1445

[0034] Below, the example of the amendment approach between gain factor a and the facility by the degree of the offset multiplier b is explained at a detail.
[0035] Photography of an X-ray photograph film required for this osteometry approach of this invention is performed by carrying out like drawing 1 . The cassette of dedication by which 1 put X-rays equipment and 4 put an X-ray photograph film and the intensifying screen in drawing 1 , and 3 are criteria phantoms. The photoed X-ray photograph film is developed by an auto-processor, similar equipment, or the help. Although a criteria phantom should just use two or more kinds of things, it uses three kinds of things here. The configuration of a criteria phantom is shown in drawing 11 . Furthermore, the example of the geometry of each criteria phantom is shown in Table 3. Three kinds of criteria phantoms are measured after photography by the same approach also in other facilities. Distribution between the facilities of the measurement result of each criteria phantom is shown in drawing 12 .
[0036] Table 3 shows the bore and outer diameter of a criteria phantom of three types in the equipment of this invention.
[0037]
[Table 3]

基準ファントム	内径 mm	外径 mm
骨細タイプ	3．4	5．0
標準タイプ	3．0	5．0
骨太タイプ	2．6	5．0

寸法公差：±0．02

[0038] It sets to each facility and is [0039].
[Equation 3]
X軸を

$$\Sigma GS_{dsgn} = \Sigma GS/D_{dsgn} \times D_{dsgn}$$

Y軸を

$$\Delta = \Sigma GS/D_{meas} \times D_{meas} - \Sigma GS/D_{dsgn} \times D_{dsgn}$$

[0040] A degree type is obtained by writing the graph (drawing 14) carried out and recurring temporarily.
[0041]
[Equation 4]

$$\Delta_{revolved} = a \times \Sigma GS_{dsgn} + b$$

[0042] Here, ** and a **revolved was presumed to be by primary recursion express a gain factor, and b expresses an offset multiplier. Bone measurement result sigmaGS/Dmeas can be amended to a value with few differences between facilities using this formula. A correction formula is shown by the degree type.
[0043]
[Equation 5]

$$\Sigma GS/D_{mdfd} = \frac{\Sigma GS/D_{meas} \times D_{meas} - b}{(1 + a) \times D_{meas}}$$

[0044] Here, sigmaGS/Dmdfd is as a result of [after amendment] an osteometry. As a result, even if it measures three kinds of criteria phantoms with the osteometry equipment after photography, a thing with distribution between facilities like drawing 12 can amend to the distribution which does not almost have a difference between facilities like drawing 15 . Moreover, even if it sees with the difference between facilities, effectiveness as shown in Table 4 is accepted.
[0045] Table 4 shows the effectiveness when performing gain offset amendment in the equipment of this invention.
[0046]
[Table 4]

		基準ファントム		
		骨細	標準	骨太
施設A		1.8439	2.2226	2.5249
施設B		1.8599	2.2046	2.5575
施設C		1.8402	2.2130	2.5335
施設D		1.8512	2.1901	2.5498
施設間差	補正後	0.0197	0.0325	0.0326
	補正前	0.1189	0.1455	0.1445

[0047] The tested bone needed when performing various osteometries, such as a check of the range of the class of osseous lesions, such as a growth condition of human being's bone, a check of seniliy or osteoporosis, and osteomalacia, or the percentage of completion of the symptom, and the effectiveness at the time of a therapy, as an example of analyte applicable to the osteometry approach of this invention is raised. Be [what is necessary /just although an X-ray photograph film with whenever /to some extent clear shading /is obtained as a tested bone in the case of using an X-ray photograph film], what the layer of the soft tissue section is usually equalizing thinly is desirable. As an example, the long long bone which consists of cortical bones, such as a bone of hand, a humerus, a radius, an ulna, a femur, a tibia, and a fibula, is raised. As other examples of a tested bone applicable to the equipment of this invention furthermore, cancellous bones, such as an epiphyseal area of a calcaneus, a spine, and the above-mentioned long long bone, are raised. Moreover, as long as it is required to convert into the thickness of the standard substance and to evaluate through an X-ray photograph film as other specimen, you may be what kind of thing.

[0048] The osteometry equipment of this invention is characterized by having a configuration for enforcing this osteometry approach. Drawing 16 is typically shown as a desirable example of a mode of the osteometry equipment of this invention. In this drawing, a generating means (light source) of light by which the automatic reading function part 10 irradiates an X-ray photograph film, the detection means for detecting the reinforcement of the transmitted light to which the light from that light source penetrated the X-ray photograph film, and in order to make it run an X-ray photograph film automatically, it has a film automatic transit means.

[0049] Although spot-like light is generated as this light source, in order a scanning means is usually needed and to make it the equipment which is small and simple structure, the band-like light source for generating a band-like light is suitable practically. Moreover, the transmitted light is detectable, and corresponding to it, adhesion image sensors band-like in a band-like sensor, i.e., a line sensor, are desirable especially desirable [as long as automatic reading is possible, what kind of thing may be used but] as a detection means, when using the band-like light source practically. It may be other, although a roller is usually used as a transit means of a film and the roller of a pair which rotates to an opposite direction mutually on both sides of a film in between especially is used suitably. In addition, as long as it can run an X-ray photograph film as an automatic transit means of a film at the rate of predetermined with the rate which suited the detection rate of a detection means, you may be what kind of thing, and a transit format may be

continuous or may be intermittent.
[0050] As for the osteometry equipment of this invention, it is desirable to provide an image storage means. If the data constellation which made the digital signal about the reinforcement of the transmitted light in the image in the X-ray photograph film of the tested bone obtained by the automatic reading means like the above correspond to the location of a film as this image storage means, or the data constellation about the image converted into the thickness of a reference material can be memorized, you may be what kind of thing and the storage memory size will be chosen according to the purpose of an osteometry. As an example, the computer means like about 2 M bytes of image memory etc. is raised in the osteometry of the 2nd os metacarpale.
[0051] Moreover, to the equipment of this invention, an operation means to perform various processings for performing an osteometry using the image read in the film possesses.
[0052] Moreover, as shown in the equipment of this invention at drawing 16 , were read by the image reading means. Or the image display means like CRT (Cathode Ray Tube) for displaying as an image the image of the tested bone memorized by the storage means, Equipment with the operation means for performing the operation for the osteometry about the image of the tested bone memorized using the criteria point inputted as the point input means for inputting the criteria point required for an osteometry in the image of the displayed tested bone is contained.
[0053] If the data constellation which consists of relation of the digital signal and location which were memorized or obtained by the image storage means with the automatic reading means as this image display means can be displayed as an image, you may be what kind of thing and CRT etc. will specifically be raised from the cost of resolution as a suitable example.
[0054] for example, as a point input means for inputting the point of the criteria in the case of asking for the midpoint of the 2nd os metacarpale by the image of CRT As long as it can pinpoint and input a location as the criteria point in an image display means, you may be what kind of thing. As an example The approach of inputting automatically etc. is raised from the image of the tested bone memorized by the approach list inputted from the exterior with a cursor location display, a directions control means, a light pen blocking force means, and a touch panel.
[0055] Come, whenever it is shown in drawing 16 , and the equipment of this invention is made to memorize the location of the criteria point inputted by the point input means in the image display means before adjusting the quantity of light of the light source with storage means, such as RAM. Subsequently, like the above, the film of the same part is again read with the accommodation quantity of light after adjusting the quantity of light based on a judgment result, and the thing possessing the means for carrying out a point input based on the criteria point already memorized by RAM in the image displayed on the display means is contained. Actuation of these single strings is made by the image reading function part 10 which operates by control of MPU in drawing 16 . When resetting of the exposure quantity of light is made and it differs from the set point last time by this configuration, a film is automatically sent to an aluminum stairway and an object part, and since the last point input value is memorized and processing is automatically performed in the location when the point input of the part for reading is required, the burden of the operator for reinput can be reduced.
[0056] Moreover, if the measurement result obtained by the operation can be outputted as an osteometry output means in the osteometry equipment of this invention, you may be what kind of thing and a dot type ink printer, a thermal printer, a laser beam printer, a video printer, other CRT screens, etc. will be raised to hard copy as an example.
[0057] In addition, in the reading function part 10 shown in drawing 16 , the line sensor (CCD:Charged Coupled Device) which consists of 65-micrometer pitch x4096 child, for example is arranged in a right angle in the film migration direction. A film is irradiated according to the band-like light source (LED:Light Emitting Diode) from an X-ray photograph film top face or an inferior surface of tongue. The transmitted light is condensed in this film reflector by the rod lens arranged so that a focus may be connected on a line sensor. The very small film transit means using the pulse motor which can carry out very small migration in 65-micrometer pitch is provided in a line sensor and the band-like light source, and the direction of a right angle at the same time it acquires signals, such as reinforcement of the transmitted light according to the X-

ray photograph film density. Moreover, each component of a line sensor outputs the analog voltage proportional to the amount of incident light to a line sensor (= the amount of transmitted lights according to the shade to a film).

[0058] To the specific part in this X-ray photograph film, a crimp enables detection of the transmitted light or the control means for controlling making it run a film intermittently at the rate of predetermined is illustrated as a film feed controller in drawing 16 .

[0059] In addition, the CCD driver in drawing 16 has the function controlled to be able to take out the data stored in CCD to predetermined timing.

[0060] Moreover, in the osteometry data processing function section in drawing 16 , the data constellation read by the reading function part 10 is memorized by the image storage means which mainly consists of the image I/O section and image memory in the data-processing section 11. The data constellation about the memorized image is displayed by CRTC and CRT.

[0061] Since the image of the os metacarpale is displayed and a measurement part is pinpointed by 7 inch CRT (640 dots x 400 lines) which has an image display means and a point input means, cursor is moved and the condyle and epiphysis are directed. This point input means is shown as KBI/F and a keyboard in drawing 16 .

[0062] The operation for an osteometry is performed in the operation means which mainly consists of ROM (program store section for an operation) and RAM (part which calculates and memorizes a result) in drawing 16 .

[0063] The obtained osteometry result is outputted by the output means which mainly consists of PRI/F and the printer in drawing 16 . It is for connecting with RS-232C and MODEMF, and other equipments.

[0064] MPU in drawing 16 is a 16-bit microprocessor which controls incorporation of the data to image memory, a startup and halt of a program, a keyboard, CRT, etc. other than the above mentioned function, and PIO functions as an interface for outputting and inputting digital control I/O to the above-mentioned computer system.

[0065] About use of the correction formula which is the description of the equipment of this invention, a phantom is beforehand changed, for example in a facility, an osteometry is performed, the multiplier of the correction formula is inputted into the equipment of drawing 16 , and ROM is made to ask for the correction formula and to memorize it like the above-mentioned. In the case of actual measurement of a tested bone, the correction formula which used those multipliers in ROM is adopted, and it is made to process an osteometry at it.

[0066] Although the example mentioned above showed what used the X-ray photograph film, this invention is easily applicable to the equipment which irradiates and images a direct X-ray to X-ray image sensors. The flow to an osteometry is typically shown in drawing 17 from the roentgenography in the case of this equipment.

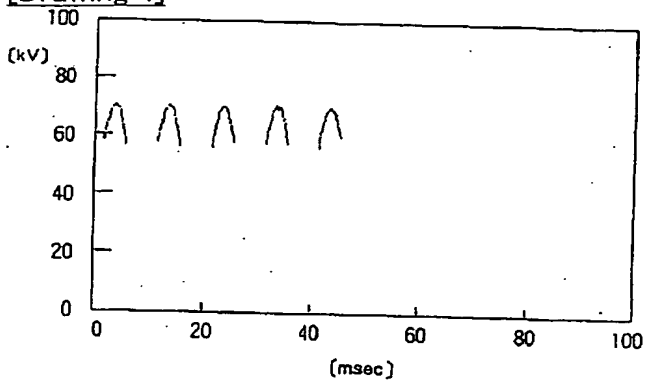
[0067] In the equipment which irradiates and images a direct X-ray to X-ray image sensors, roentgenography can be performed using an imaging plate 12 instead of the cassette which put the X-ray photograph film in the conventional roentgenography, and the information which is proportional to the X-ray information by which are recording record was carried out at this imaging plate 12 by the laser Mitsuteru gunner stage 13 and the optical detection sensor 14 by irradiating laser light at X-ray intensity can be read as a lightwave signal. A/D conversion of the read photoelectrical information is carried out, and X-ray image 15 of a tested bone is obtained. An osteometry with this X-ray image equivalent to the osteometry approach in this invention can be performed.

DESCRIPTION OF DRAWINGS

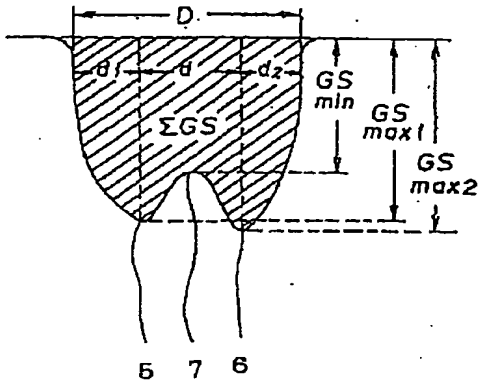
[Brief Description of the Drawings]
[Drawing 1] Instantiation of photography of the X-ray photograph film for osteometries
[Drawing 2] Relation between the tube voltage in X-rays equipment, and X-ray wavelength
[Drawing 3] Instantiation of change of the mass attenuation coefficient accompanying tube voltage change
[Drawing 4] Instantiation of wandering of the tube voltage at the time of taking a photograph with X-rays equipment (single phase)
[Drawing 5] Setting tube voltage at the time of X-ray photograph filming, and instantiation of correlation of an osteometry result
[Drawing 6] Instantiation of an auto-processor
[Drawing 7] Instantiation of the development nonuniformity by the auto-processor (the direction of a film advance)
[Drawing 8] Instantiation of the distribution between facilities of an osteometry result
[Drawing 9] Instantiation of the osteometry in the equipment of this invention
[Drawing 10] Instantiation of correlation of sigmaGS/D in an osteometry result, and sigmaGS
[Drawing 11] Instantiation of the criteria phantom configuration in the equipment of this invention
[Drawing 12] Instantiation of the distribution between facilities of the criteria phantom osteometry result of three types in the equipment of this invention
[Drawing 13] Instantiation of the distribution between facilities of the osteometry result after the offset amendment in the equipment of this invention
[Drawing 14] sigmaGS design value of each criteria phantom and relation of ** to the equipment of this invention
[Drawing 15] Instantiation of the distribution between facilities of the osteometry result after the gain offset amendment in the equipment of this invention
[Drawing 16] What illustrated the equipment of this invention typically like a block flow diagram.
[Drawing 17] Drawing having shown typically the flow from the roentgenography in the osteometry equipment which used X-ray image sensors to an osteometry
[Description of Notations]
1 X-rays Equipment
2 Standard Substance from which Thickness is Changing
3 Criteria Phantom
4 Cassette of Dedication Which Put X-ray Photograph Film and Intensifying Screen
5 GSmax1 in Bone Pattern
6 GSmax2 in Bone Pattern
7 GSmin in Bone Pattern
8 False Soft Tissue
9 False Bone
10 Automatic Reading Function Part
11 Data-Processing Section
12 Imaging Plate
13 Laser Mitsuteru Gunner Stage
14 Optical Detection Sensor
15 X-ray Image of Tested Bone

DRAWINGS

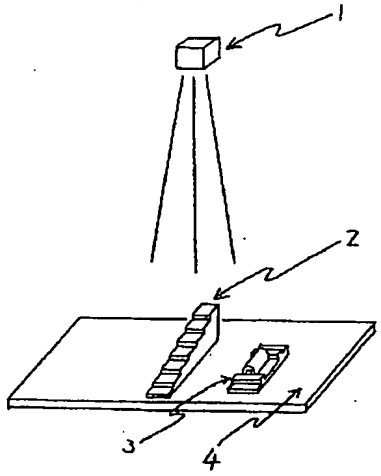
[Drawing 4]



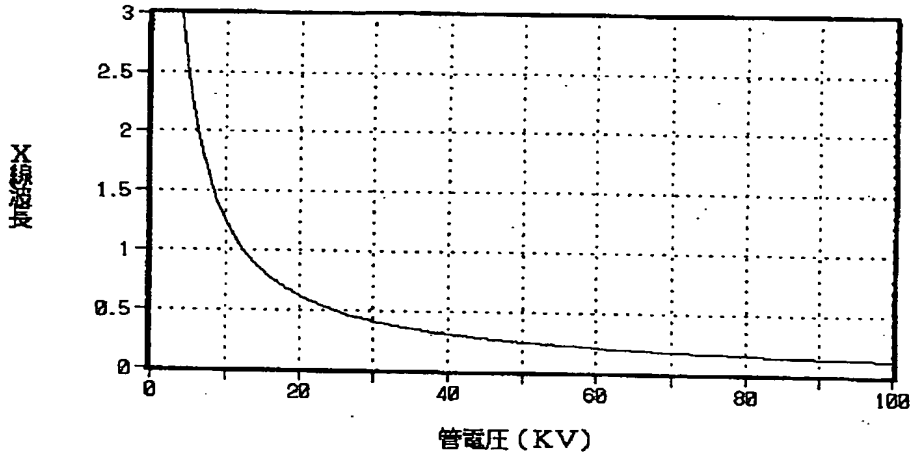
[Drawing 9]



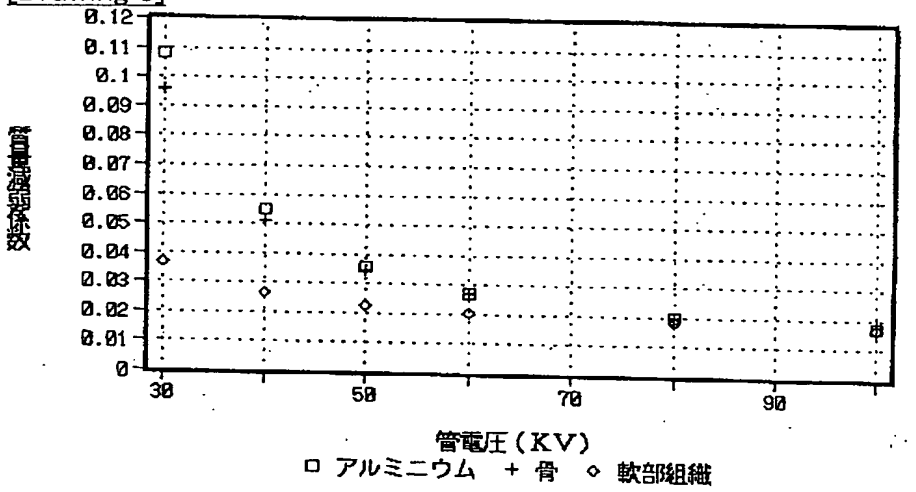
[Drawing 1]



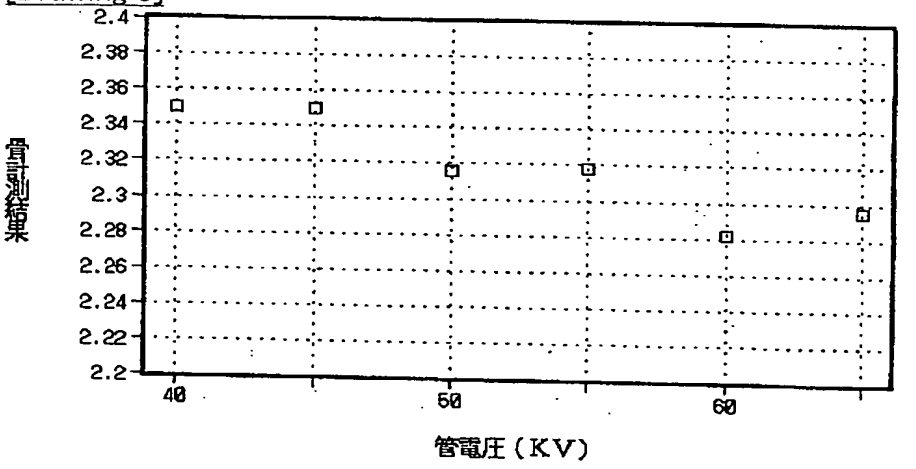
[Drawing 2]



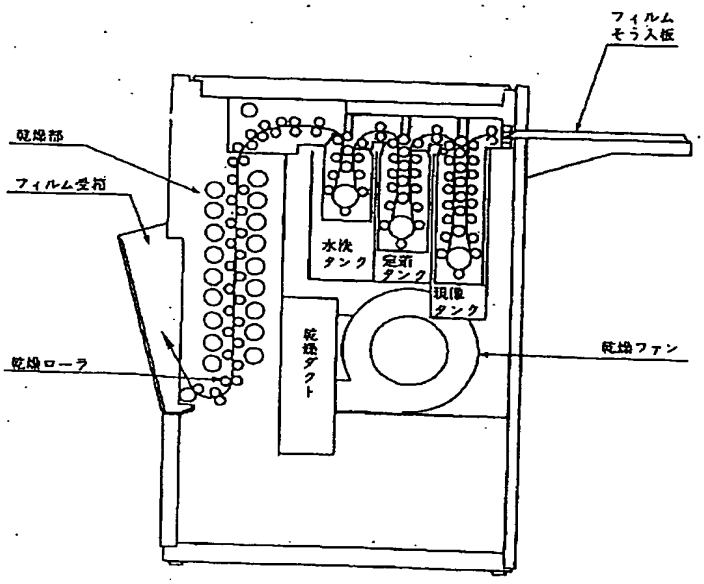
[Drawing 3]



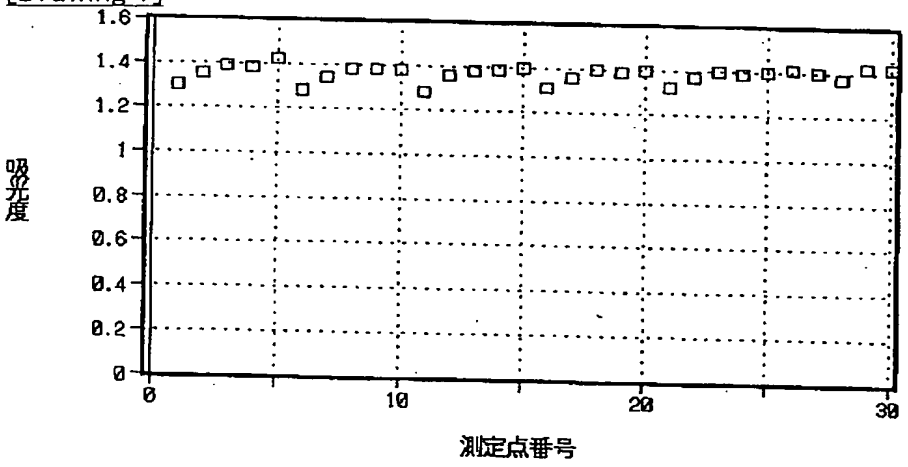
[Drawing 5]



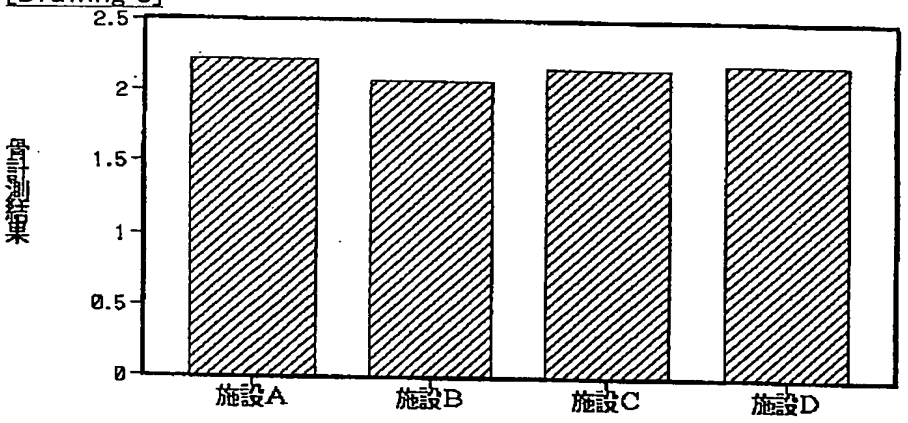
[Drawing 6]



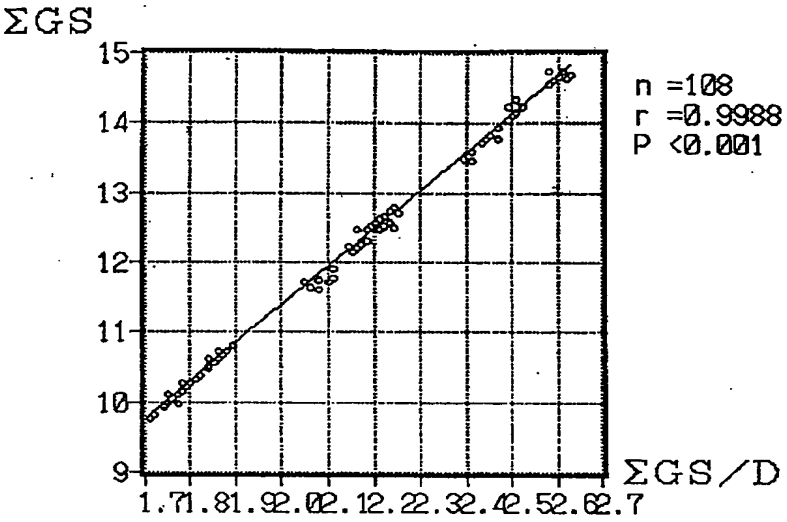
[Drawing 7]



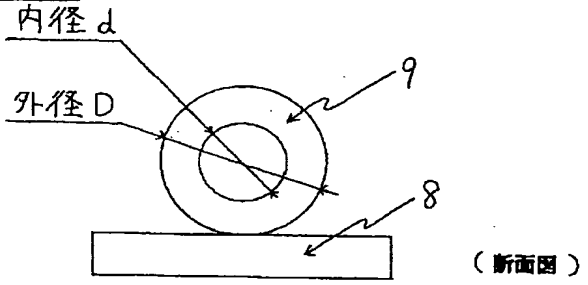
[Drawing 8]

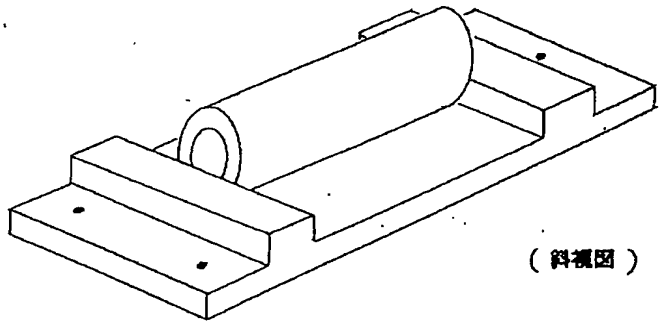


[Drawing 10]

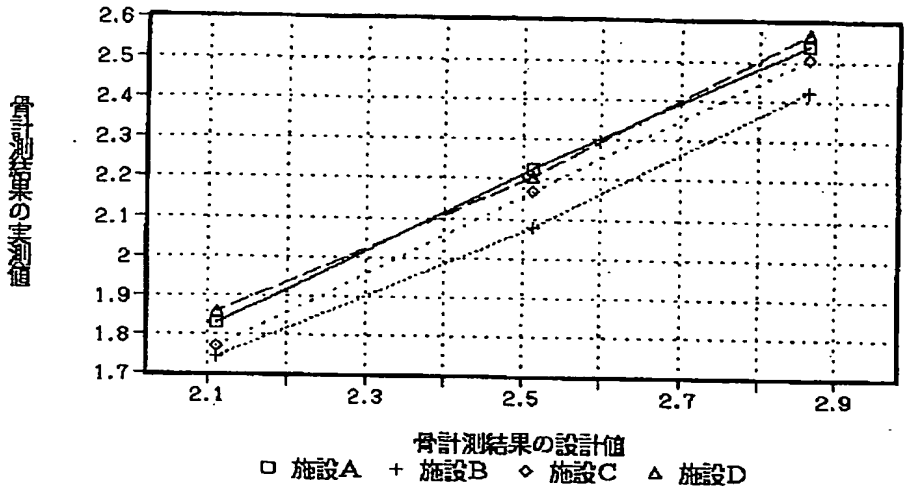


[Drawing 11]

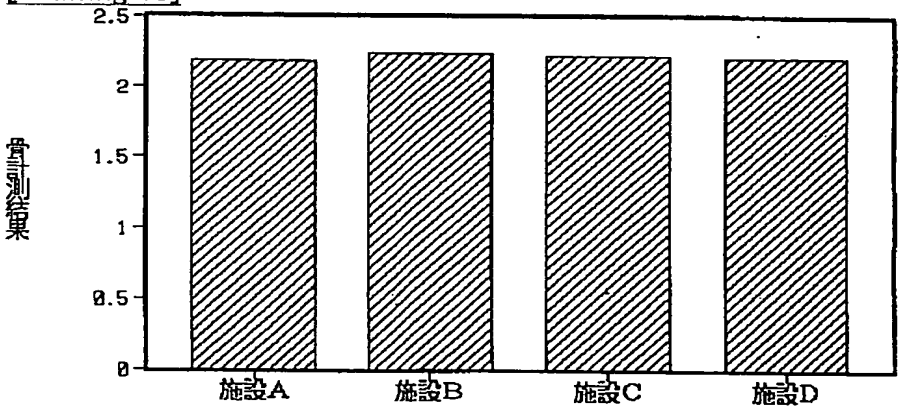




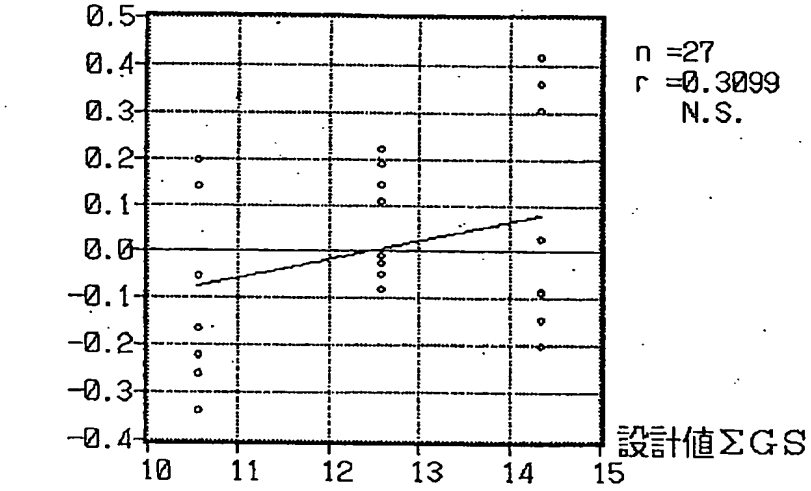
[Drawing 12]



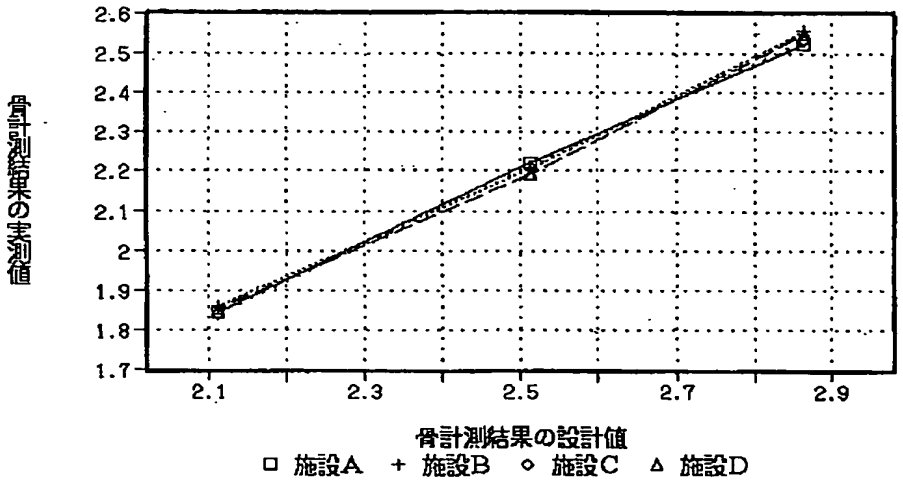
[Drawing 13]



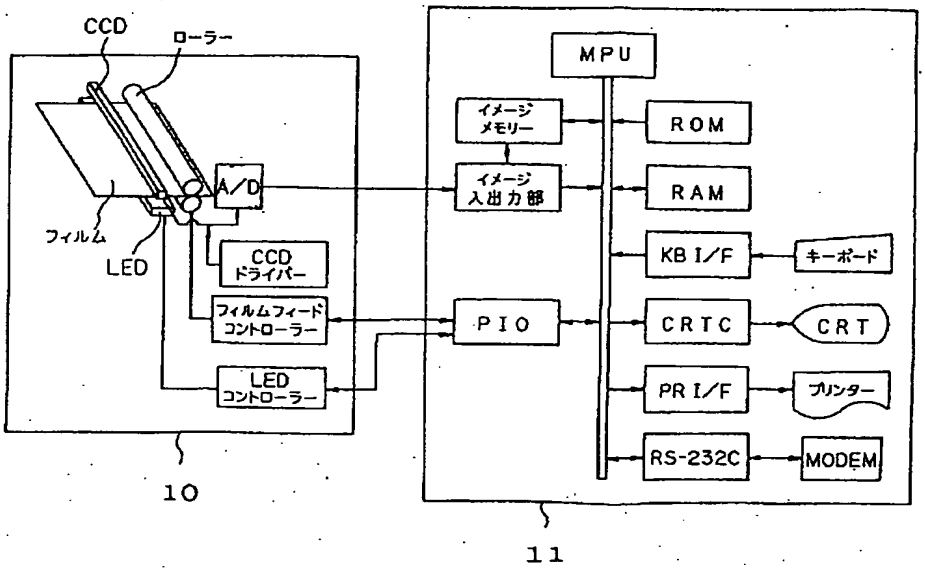
[Drawing 14]



[Drawing 15]



[Drawing 16]



[Drawing 17]